"DESIGN PROPOSAL OF THE HERITAGE-INSPIRED PROMENADE BRIDGE FOR A SUSTAINABLE OLD BAGBAG BRIDGE IN CALUMPIT , BULACAN "

An Experimental Research

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Bachelor of Science in Civil Engineering

Major in Construction Engineering

and Management

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RECOMMENDATION

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CERTIFICATE OF ORIGINALITY

This document is a Certificate of Originality for the research entitled "Design Proposal of the Heritage-Inspired Promenade Bridge for a Sustainable Old Bagbag Bridge in Calumpit Bulacan". This certifies that the original work of the researchers has not been previously written, published, or submitted by any other individual or institution, except where due acknowledgment and proper referencing have been made.

Furthermore, the researchers declare that the intellectual content of this study is the result of their own efforts, ideas, and collaboration, expressed in a clear and straightforward manner consistent with their intent and presentation.

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CHAPTER 1

The Problem and its Background

This chapter presents the overview of the study including the introduction, background of the study, theoretical framework, statement of the problem, hypotheses, scope and limitations of the study, significance of the study, and definition of terms.

Introduction

The Bagbag Bridge, in Calumpit, Bulacan, is a historic structure that played a valuable role during the Philippine–American War. The Battle of Calumpit, otherwise called the Battle of Bagbag and Pampanga Rivers, was fought on April 25 and April 27 in the year 1899, in the area of Calumpit, Bulacan. General Gregorio del Pilar skillfully utilized the Bagbag railway bridge in order to slow down the advance of the American army. The iron girders of the bridge were cut by Filipino warriors, preventing the advancement of American armored train. Although the move created only a temporary setback on the part of the American army, they were, in fact, later able to rebuild it and cross the river (Agoncillo, 1960; Zaide, 1994).

The existing structure by the old site currently does not match the bridge involved in the 1899 war. Historical evidence and investigations into the site confirm that the original iron railway bridge was either destroyed or disassembled in the end.

The existing bridge made of concrete is a replacement and has no direct material connection with the war incidents (Layug, 2012). Currently, the replacement bridge falls under the class as non-functioning and has been barred from public use due to the deterioration in its condition (Inquirer News, 2013). Despite its existing status as disuse, Old Bagbag Bridge remains a historical marker symbolizing Filipino sacrifice and resilience. The study aims to propose a new bridge acting as a promenade bridge with a heritage-inspired design. The design should involve both commemorative monument and useful passage for the community. Through the application of ideas drawn from structural engineering, sustainability, and heritage conservation, the proposed design aims to offer lasting, safe, and culturally meaningful infrastructure fitting the commemoration as well as meeting the modern need of the community (Szmelter, 2020; Marchese et al., 2018; Galambos, 1981).

Background of the Study

"Old buildings are like a book. You can open it and read the history of a place, of a people, of a civilization" – Richard Henriquez. With that statement from Architect Richard Henriquez, Historic infrastructure holds significant aspects in today's structures. Given that the Old Bagbag Bridge contains historical importance, it is needed to remodel the existing bridge to honor its legacy and the history it holds, while providing a safe and accessible public space.

The Purpose of this study is to propose a new structural plan for construction to the location of the existing bridge. The researchers aim to do a design-only study

to propose a bridge that will have features that commemorate the events of the fight in 1899 and be limited only to pedestrian and bicycle use. The study aims to offer a practical way to preserve its local heritage while keeping value to the community with the use of accessible and meaningful design. And in addition the study aims to propose a heritage-inspired design and to enhance the durability of the structure, improve the safety and functionality. The proposed structural design is to replace the old bridge with a more sustainable public pedestrian bridge.

As an illustration to explain why the researchers aim to propose a heritage-inspired design, let's take Mostar's Old Bridge in Europe. The bridge was destroyed in 1993 during Bosnian War. In 2004 using identical materials and traditional techniques reconstructed and became a global symbol of peacebuilding. The bridge now serves as a powerful presentation of harmony, resilience and reconciliation between several ethnic communities in addition to being a symbol of architectural rebirth. Not only that but also what they did on the historic Zapote Bridge in Las Piñas-Bacoor Cavite. Half of the bridge collapsed during a war that happened on February 16, 1897. The restoration of the bridge was funded by Congresswoman Villar and became a pedestrian promenade bridge with monument park on both ends of the bridge.

Theoretical Framework

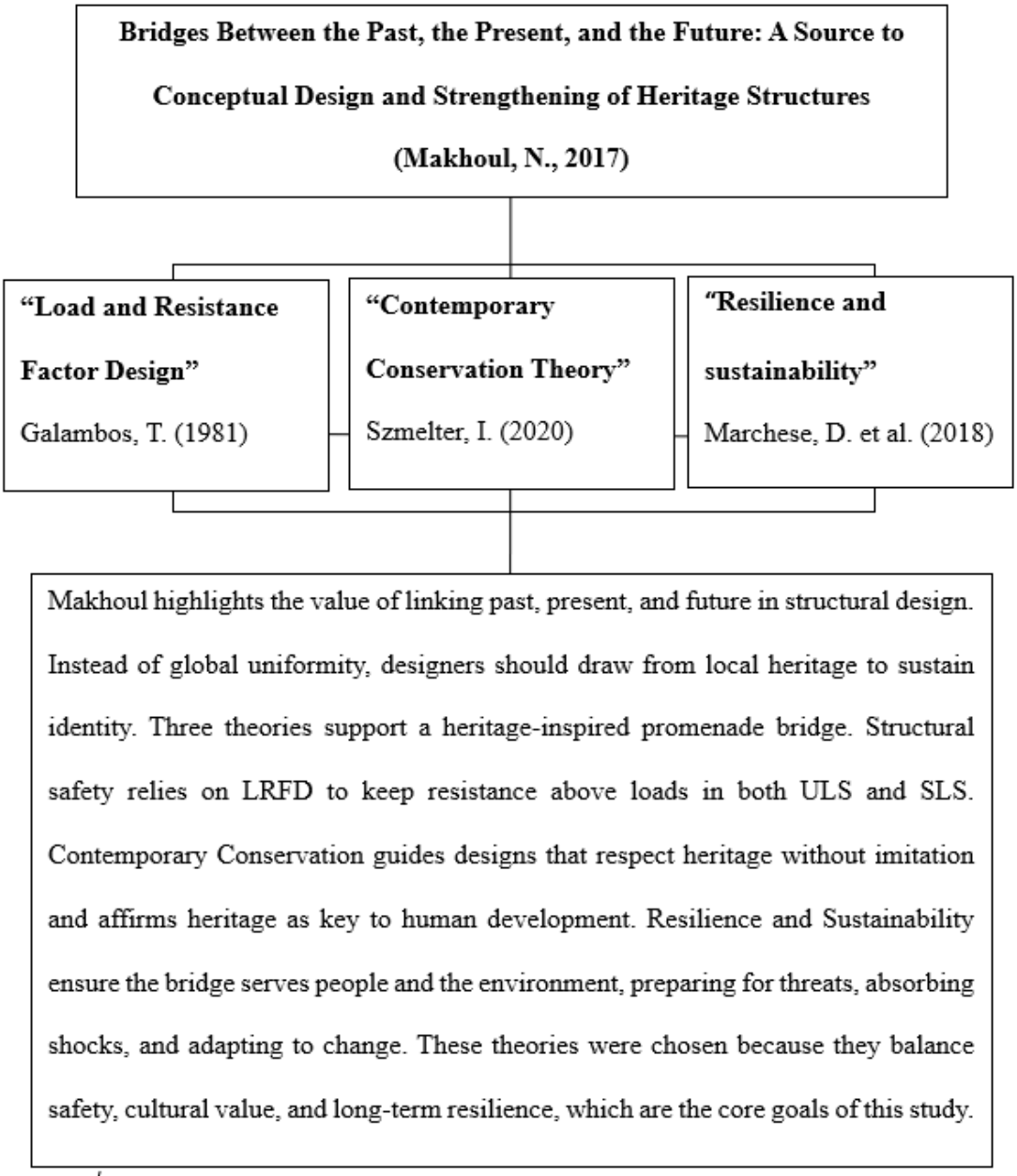
Bridges Between the Past, the Present, and the Future: A Source to Conceptual Design and Strengthening of Heritage Structures (Makhoul, N., 2017)
"Load and Resistance Factor Design" Galambos, T. (1981)
"Contemporary Conservation Theory" Szmelter, I. (2020)
"Resilience and sustainability" Marchese, D. et al. (2018)
Makhoul highlights the value of linking past, present, and future in structural design. Instead of global uniformity, designers should draw from local heritage to sustain identity. Three theories support a heritage-inspired promenade bridge. Structural safety relies on LRFD to keep resistance above loads in both ULS and SLS. Contemporary Conservation guides designs that respect heritage without imitation and affirms heritage as key to human development. Resilience and Sustainability ensure the bridge serves people and the environment, preparing for threats, absorbing shocks, and adapting to change. These theories were chosen because they balance safety, cultural value, and long-term resilience, which are the core goals of this study.

Figure 1: *The theoretical framework illustrates theories from different studies.*

IPO Conceptual Framework

INPUT	PROCESS	OUTPUT
1. Demographic Profile 1.1 Age 1.2 Type of Respondents	● Survey Questionnaire	● Acquire respondents perception
2. How will the proposed design be cost-efficient while ensuring: 2.1 Safety provision of users 2.2 Functionality as a promenade 2.3 Preservation of cultural heritage	● Cost Estimate ● Use Cost-Efficient but durable materials that lower maintenance cost	● Cost efficient material and construction plan
3. How the proposed design structure ensure durability in terms of: 3.1 climate conditions 3.2 flood events 3.3 soil conditions	● Design the structure accordance to the Load and Resistance Factor design	● Structural performance evaluation under climate conditions, flood events and soil condition
4. How can the proposed design enhance public awareness and appreciation of the historical importance of Bagbag Bridge in terms of: 4.1 tourism 4.2 historical awareness 4.3 public engagement	● The design will incorporate elements that highlight historical significance	● Historical and cultural design features
5. How can the proposed bridge meet modern engineering standards and sustainability requirements in terms of:	● Use simulation to analyze the loads and stresses	● Safety and accessibility features

5.1 Design loads and safety factors 5.2 Choice of materials 5.3 Structural design considerations 6. How effective is the projected service lifespan of the bridge under normal usage and environmental conditions in terms of: 6.1 Load capacity performance 6.2 Long-term safety and stability 6.3 Accessibility for pedestrians and cyclists	● Will be evaluated through LRFD-based structural analysis using STAAD Pro to assess load capacity, stability, and durability.	● Expected long term performance in terms of load capacity, stability and maintenance requirements

Statement of the Problem

The purpose of this research is to propose a design for the Old Bagbag bridge at Calumpit Bulacan that meets the engineering standards while maintaining its historical importance that can serve as a functional pedestrian and park for the public. The study aims to answer the following questions:

1. Demographic Profile

    1.1 Age

    1.2 Type of respondents

    Type of Respondents

2. How will the proposed design be cost-efficient while ensuring:

    2.1 Safety provision of users

    2.2 Functionality as a promenade

    2.3 Preservation of cultural heritage

3. How the proposed design structure ensure durability in terms of:

    3.1 climate conditions

    3.2 flood events

    3.3 soil conditions

4. How can the proposed design enhance public awareness and appreciation of the historical importance of Bagbag Bridge in terms of:

    4.1 tourism

    4.2 historical awareness

    4.3 public engagement

5. How can the proposed bridge meet modern engineering standards and sustainability requirements in terms of:

    5.1 Design loads and safety factors

    5.2 Choice of materials

    5.3 Structural design considerations

6. How effective is the projected service lifespan of the bridge under normal usage and environmental conditions in terms of:

6.1 Load capacity performance

6.2 Long-term safety and stability

6.3 Accessibility for pedestrians and cyclists

Objective of the Study

The objective of this study is to propose a design for the Bagbag bridge at Calumpit Bulacan that meets the engineering standards that promotes sustainability and accessibility to the community while maintaining its historical importance that can serve as a functional pedestrian and park for the public.

Specifically, the objectives of this study:

1. To determine the demographic profile of the survey participants.

1.1 Age

1.2Type of Respondents

2. To Propose a cost-efficient bridge design that ensures:

2.1 Safety provision of users

2.2 Functionality as a promenade

2.3 Preservation of cultural heritage

3. To establish design strategies that will ensure structural durability in terms of:

    3.1 climate conditions

    3.2 flood events

    3.3 soil conditions

4. To enhance public awareness and and appreciation of the history impotence of Bagbag Bridge through

    4.1 tourism

    4.2 historical awareness

    4.3 public engagement

5. To ensure that the proposed design meets the modem engineering standards and sustainability requirements in terms of:

    5.1 Design loads and safety factors

    5.2 Choice of materials

    5.3 Structural design considerations

6. To determine the projected service lifespan of the bridge under normal usage and environmental circumstances in terms of:

    6.1 Load capacity performance

    6.2 Long-term safety and stability

    6.3 Accessibility for pedestrians and cyclists

Significance of the Study

This research will address the current state of the non-operational Old Bagbag bridge that's no longer suitable for public use due to its partially collapsed structure. The proposed structural design for the Old Bagbag bridge is to make a promenade and heritage-inspired design to provide safety and functionality will be beneficial to the following:

Historical and Cultural, this study will preserve the memory of the Battle of Calumpit in (1899) by integrating commemorative features to the bridge. It will honor the role of Bagbag Bridge in Philippine History, providing a tangible space for reflection and education. It will also promote cultural identity by integrating heritage-inspired design into modern infrastructure.

Local Community of Calumpit, Bulacan, the proposed bridge will serve as a functional public place that can be used by its local community. This will give them a place for walking, cycling, leisure, and community gathering. And since there is a school near the area of the proposed study, this can also serve as a new route for those students who only walk to school.

Engineering and Academic, this research will serve as a valuable reference for the design of historic bridges that prioritize the safety, stability and durability while complying with the standard specifications of Load and Resistance Factor Design (LRFD).

Environmental and Sustainability, this study will help with the demonstration of sustainable construction practices and climate resilient

design. It can also promote that the infrastructures are not just the present need but also their long-term performance impact.

Future researchers, this will open an opportunity for them to be more inclined to develop old historical infrastructure to be known as a part of history.

Scope and Limitation of the Study

This study is limited to the conceptual and structural design of a new heritage-inspired pedestrian promenade bridge using the LRFD approach in accordance with NSCP 2015. It will focus on planning and designing the bridge's structural components, ensuring the safety, stability, and durability according to the seismic design specifications of the Department of Public Works and Highways (DPWH) and other relevant standards. Also, this aims to make the bridge more functional, providing a safer paved public walk for the group of individuals.

This research is limited to a detailed structural plan, basic architectural design, and associated cost estimates. In addition, this study has its own boundary; the proposed structural design will serve its primary objective of providing a safe and functional as a promenade bridge with no vehicle included.

Definition of Terms

Accessibility - Refers to the ease and safety of future users.

Commemorative - Refers to design elements applied in the honoring and retention of the memory of the past events, in this case, the Battle of Calumpit derived from multiplying

Contemporary Conservation - Is an evolutionary methodology in the building preservation field that is equal in emphasis on the physical characteristics of structure as upon their cultural interpretations and meaning. (Smelter, 2020)

Cost-Efficient - refers to maximizing the profitability using the least amount of resources without compromising its quality.

Durable - Capacity of the bridge to withstand long use in change in environment conditions, as well as natural hazard, while experiencing minor decomposition.

Engineering Standard - An established guidelines and regulations to ensure the safety, quality and functionality of the infrastructure.

Functionality - It is how well the bridge succeeds in fulfilling its function as a passageway of pedestrian and cycle use while offering cultural value and community value.

Heritage Conservation - It involves the protection of the historical location, building, and the associated cultural values for both the present and future generation.

Heritage-Inspired Design - It is about the architectural and engineering practices that integrate elements with historical or cultural relevance with modern-day infrastructure, in the process paying tribute and reflecting it on the past.

Historical Infrastructure - An infrastructure that existed in the past and served its purpose to the communities for the long time.

Load Capacity - the capacity that can safely be handled by the proposed bridge without the possibility of collapse.

Load and Resistance Factor Design (LRFD) - A structural engineering design method that uses a set of factored load combinations and factored resistances.

Peacebuilding - a systematic effort that seeks to bring peace and co-existence, often by reconstruction of a cultural heritage structure just like the Mostar's Old Bridge in Europe.

Promenade - It is a passageway or walkway for pedestrians that is built with leisure or free time activity.

Reconciliation - Reestablishment of relations and harmony, often revealed in terms of heritage-related patterns that mirror shared heritage.

Resilience - The capacity of the bridge in adapting and continuing to perform effectively under unfavorable conditions, like floods, earthquake, or other environmental stresses (Marchese et al., 2018)

Safety - The condition of being shielded from injury, danger, or harm through the application of preventive techniques and compliance to the design standards of the infrastructure..

Serviceability Limit State (SLS) - A condition where a structure or component, despite being safe from collapse, still functions correctly and without impairment to its users.

Sustainability - A practice of meeting present-day needs without compromising the ability of future generations to meet their own.

Thoroughfare - A path forming a route between two places.

Ultimate Limit State (ULS) - Refers to the design criterion that ensures a structure has sufficient strength and stability to withstand extreme load conditions and avoid catastrophic collapse or failure

CHAPTER 2

Review of Related Literature and Study

This chapter represents a review of related literature and studies, following a thorough search done by local and foreign researchers. Those included in this chapter aid in familiarizing with relevant and related information to the current study.

Foreign Literature

According to Buchel (2025), The proposed transformation of the Old Rail Way Bridge in Trenčín, Slovakia into a promenade bridge demonstrates how an abandoned transportation bridge can be recreated into a balanced heritage preservation with a modern public needs. While the bridge no longer functions for rail traffic the heritage advocates along with its city officials visualize the use of the bridge for its community to serve as a place of people for walking, leisure, and highlight both the history and its re-establishment into urban life. Although the project isn't done yet, it shows that heritage-inspired promenade bridge projects are becoming more popular around the world. These projects preserve or reinterpret existing buildings for cultural and environmental reasons.

PMI Phoenix (2025) stipulates that adaptive reuse involves the recycling of obsolete infrastructures for different use without subjecting them to a loss of historic and cultural integrity. Adaptive reuse enhances sustainability through reduced construction wastages, fosters the vitality of communities through their economic

and tourist value, and cultivates cultural identity through preservation of inherent characteristics. Realistic applications such as New York's High Line and London's Tate Modern demonstrate that reuse projects through adaptation can bring functional, people-centered spaces without the degradation of heritage. In practical application, this principle aids heritage-based bridge design itself, with both past history and modern usability in such a way as to present safe, long-term, and culturally appropriate infrastructure.

Siviero and Martini (2021), state that the bridges written in UNESCO World Heritage list illustrate how technical innovation and cultural identity can be integrated in infrastructure. Bridges across the world like the Forth Bridge in Scotland, the Iron Bridge in England, the Mostar Bridge in Bosnia and Herzegovina, the Vizcaya Bridge in Spain, and the Oporto bridges in Portugal as examples where engineering progress and cultural symbolism converge. These Bridges demonstrate not just the monument in material and structural progress, but also sustainable cultural landmarks that inherit the history of their respective communities. The design justifies the argument that infrastructure can be functional design and cultural memory by treating technical performance and cultural value as interconnected, and justifies the proposed heritage-focused promenade bridge at Calumpit as it centers on highlighting the necessity for balancing engineering strength with historical significance.

According to Pedata et al. (2024), such heritage buildings are strategic possibilities when reframed not just as passive monuments but as active

infrastructures that foster biodiversity, energy production, sociality, and urban revival. The writers interact with various case studies such as the "Viaduc des Arts" at Paris and the "High Line" at New York and formulate a methodology for creating adaptive reuse scenarios satisfying heritage, sustainability, and public function demands. Their process refines concepts of resilience, circularity, and heritage-disbursed design.

According to Cao et al. (2025), examined the balance between preservation and contemporary functionality in retrofitting China's heritage buildings. Their research integrated expert interviews with a 425-resident survey to assess gaps between preservation objectives and building performance. They found that, although structural and fire protection systems rated highly in performance, user-focused elements like accessibility and simplicity for maintenance were highly prized but poorly performing. This emphasizes a paradigm shift, where sustainability, inclusivity, and daily usability quickly are becoming central to heritage adaption. The study proposes an assessment model that integrates stakeholder perspectives into policy and design with a goal of making heritage projects relevant within current community needs. In the proposed heritage-inspired promenade bridge for Calumpit, the model emphasizes balancing commemorative value with usability, safety, and sustainability use.

Local Literature

Gadia et al.(2023), the study focuses on a proposed overpass bridge along a busy national highway in San Ramon Dinalupihan, Bataan to address the safety of the commuters', the study highlighted that safety is one of the major concerns that needed to be addressed in the community. It stated that due to increasing population and urban expansion the absence of pedestrian-friendly infrastructure on a major highway has a lack of safe crossing and gives a high risk of road accidents to thousands of individuals. Pedestrian infrastructure plays a crucial role in enhancing the community safety, accessibility and connectivity, while employing the engineering standards in line with the National Structural Code of the Philippines (NSCP), the proposed heritage-inspired design promenade for the old Bagbag bridge in Calumpit, Bulacan emphasizes the pedestrian safety, accessibility, and functionality while integrating its cultural significance.

National Museum of the Philippines (2025), stated the city of Tayabas has well preserved Spanish-era colonial bridges. The old infrastructure in the province was declared by the National Museum of the Philippines in 2011 as National Cultural Treasure (NCT), it was built using the arched constructions with the materials of adobe, limestone and molasses. Several bridges needed to be built over due to some deterioration of heritage properties that were caused by negligence and lack of awareness. On the other hand, the stone arc bridge is one of the oldest types of bridges in ancient Rome, this type of bridge has no additional support from reinforced steel and is still considered among strongest in the world, while having its

heritage-inspired design, this view that the proposed heritage-inspired design for the old Bagbag Bridge in Calimpit, Bulacan will preserve the country's rich history, culture and identity.

Cruz and Roldan, (2024), the study argues that how can integrate the culture preservation and tourism development to its objectives that affect the sustainability of cities in developing the country. The study stated that the culture heritage serves a significant role in the country, emphasizing the rich culture, history and its heritage-inspired architecture that develop, promote and generate employment opportunities, this study rationalize that the proposed heritage-inspired design for old Bagbag bridge promotes the history of battle Filipino-American War in Bagbag bridge in Calumpit, Bulacan , which a sustainable promenade bridge enhancing the safety, functionality, while preserving its cultural significance.

According to Philippine Information Agency (PIA), (2025), the celebration of the 50th anniversary of the Philippine-China diplomatic relations and the beginning of the Chinatown Revitalization project, President Ferdinand R. Marcos Jr. along with his first lady Liza Araneta-Marcos led the ceremonial lighting of Jones Bridge in Manila. The article refers to restoring Binondo’s cultural, historical place and its significance to the country’s shared heritage. It was stated by President Marcos that how can a person know a history and culture if an individual didn't experience itself.

According to Sembrano, (2025), Valenzuela City has demonstrated effective heritage conservation through recent restoration efforts that combine historical accuracy with public accessibility. The city reconstructed the prewar *bahay na bato*

of Dr. Pio Valenzuela using salvaged materials and oral accounts from descendants to guide hybrid reconstruction methods. Additionally, the rehabilitation of the Arkong Bato preserved original structural elements while adapting to present-day infrastructure needs. These projects highlight the value of commemorating cultural identity through built heritage while integrating modern use, aligning with the goals of this study to propose a heritage-inspired promenade bridge that honors the historical significance of the Old Bagbag Bridge in Calumpit

Foreign Study

According to Kovács (2021), investigated how pedestrian bridges create a modern identity for the city. They outlined that bridges have a dual role, being transport connections as well as public spaces. The case study involved Krakow, Rotterdam, and Seoul. The authors concluded that pedestrian bridges, when properly designed, enhance pedestrianability and make compelling visual symbols for the city. They make movement safer and encourage social interaction. The study emphasized the need to combine engineering efficiency with aesthetic and cultural value. You learn that design choices such as lighting, form, and material help people connect emotionally to the structure. For heritage-inspired projects, the research shows how bridge design supports tourism and strengthens local identity.

Hettinger et al. (2020), the researcher investigated the environmental performance of a prestressed concrete bridge relative to a composite bridge using life cycle assessment (LCA). They contrasted the material production, construction,

maintenance, and end-of-life stages to determine which option exhibits lower environmental impact. Their findings indicate that composite bridges generally lead concrete bridges in carbon footprint and resource usage, especially when recycling is implemented. They, however, note that the environmental performance relies significantly on the end-of-life strategy and efficient recycling infrastructure.For the proposed heritage-inspired promenade bridge, this research investigation provides a benchmark for choosing materials (composite or concrete) that are based on LCA results without sacrificing structural reliability.

Salameh et al. (2022), the researcher conducted an investigation and highlighted the heritage conservation facilitates sustainability by enhancing thermal efficiency and fostering cultural identity in Nablus, Palestine. The study involved a comparative analysis of a conserved heritage structure, Khan Al-Wakala, alongside a contemporary hotel utilizing thermal simulation methods. Findings indicated that conventional architectural characteristics, including courtyards, substantial stone walls, and dense urban configurations, effectively diminished energy consumption. The conserved structure used 7.5% less heating and 25% less cooling energy than the modern one. The study determined that the heritage-based passive designs maintain its cultural identity, lower carbon emissions and improve indoor comfort. It emphasizes that preserving the old urban fabrics strengthens social belongings and economic stability. The study proposed heritage-inspired design for Bagbag bridge, supported by this study that linked between the traditional design and modern

sustainable infrastructure and shows how integrating, climate-responsive design elements creates both environmentally efficient and culturally meaningful structures.

Chan and Iwata (2025), carried out a study on the application of advanced sensor systems for sustainable monitoring of bridges. The study stated that a structure faces multiple risks in its existence. The researchers introduced the wireless sensor that can monitor the stresses, vibrations and environmental factors in predicting structural fatigue. It concluded that sensors increase safety, lower maintenance cost and reduce time for inspections. Likewise , the system urges sustainability for the long-term maintenance of bridges by avoiding unnecessary repairs and reducing wastage of materials. Researchers find that online monitoring has the advantage that designers create bridges that constantly maintain safety and efficiency amidst changing environmental conditions. This study proves a work by showing the technological-driven design helps to sustain the durability of modern pedestrian bridges.

Oladazimi et al., (2023),the study examines residential premises in Iran with different structural materials but identical designs. It compares the environmental activity of steel and concrete construction frames using Life cycle assessment (LCA). The researchers measured energy consumption of greenhouse gases emissions , material efficiencies over building's life cycle and found out that the concrete frames had a huge possibility in terms of recyclability and had a lower long-term environmental costs. It concluded that the selection of material in the design phase has a major effect on sustainability outcomes.You learn that applying

LCA in structural design helps engineers make data-driven decisions to minimize environmental impact. For heritage-inspired projects, this approach supports sustainable material choice without sacrificing durability or safety.

Local Study

According to De Jesus et al. (2022) Building adaptive reuse had become a popular approach in conserving the structures cultural heritage mainly having two objectives of being able to preserve heritage structures and promote tourism and cultural heritage. Adaptive reuse refers to adaptation of the old structures that introduces modern purpose to the old structure. Old structures are upcycled instead of being demolished.

Rance, Roces, and Carido (2024) Their study shows the improvement and preservation of the Banyuhay bridge in Manuel S. Enverga University serves as one of their historical properties, where the said structure experiences and suffers structural deterioration that affects the safety of the people using the Banyuhay bridge. The degradation poses potential danger to pedestrians such as minor accidents that are caused by the exposed iron rods and nails. The study highlights the importance of integrating both engineering innovation and sustainability standards in accordance with BERDE green building standard.

Ebada, Valenzuela, and Quevado (2024) The study addresses traffic congestion and pedestrian safety concerns through their proposed overpass

pedestrian bridge. The study shows that small vehicles such as motorcycles, tricycles, SUV sedans ,big trucks and buses have a significant contribution to congestion, having 81% of the bottleneck during the peak hours. The study emphasizes structural integrity and prioritization of pedestrian safety by designing the said pedestrian bridge that strictly adheres to AASHTO standards and relevant regulations.

Duarte et al.(2020) the case study article expounded the stakeholders perception towards the urbanization of heritage properties, particularly the old historical walled city of Intramuros in the city of Manila with recognition of the building of the Filipino-Chinese Friendship Bridge. The case study approach is integrated in the study to recognize the arising issues from the subject site in which the outcome of the study reveals the different perspectives of the stakeholders with regards to the construction of the Filipino-Chinese Bridge between Intramuros and Binondo. In this sense, The (NGOs) such as the government and non-governmental organizations ought to inaugurate regulations with the means of protecting and conserving the different heritage properties, along with balancing the demands for immediate urbanization. As a result of urban development, heritage properties such as the integrity and significance are being compromised, which could lead to degradation of the local properties identity and culture.

Morales et al.(2022) Assessed the connection between the pedestrian experiences and the design features of the footbridges of España Boulevard in Manila prioritizing safety, accessibility, and its usability. The study examined the six

footbridges located at España-Morayta, Torre de Santo Tomas, UST Quadricentennial Pavilion, Dos Castillas, Antipolo, and Bluementrit. The study uses descriptive methods, field observations, and surveys in analyzing the physical design elements of the footbridges. The results show inadequate dimensions, lack of roofing and absence of PWD provisions affecting the pedestrian comfort and safety negatively. The study proposed a design following the standards emphasizing the accessibility, appropriate vertical clearance, safe dimensions, proper roofing, security and safety of the pedestrians. The study highlights a well-planned structure promoting the comfort, security and safety of pedestrians.

Synthesis of the Literature and Studies

Foreign and local Study conducted research unpacks shared challenges concerning sustainability, design, and cultural retention. Experts agree bridge designs should strike a harmonious equilibrium between safety, functionality, and cultural relevance. Buchel (2025) explored the Old Railway Bridge, Trenčín, Slovakia, demonstrating how a disused bridge becomes a publicly accessible promenade retaining historical value yet supporting modern needs. PMI Phoenix (2025) confirmed that adaptable reuse promotes sustainability by reducing waste and securing cultural identity. Siviero and Martini (2021) compared universally accepted heritage bridges, including the Iron Bridge and Mostar Bridge, demonstrating that bridges are both technical achievements and cultural icons. Cao et al. (2025) confirmed accessibility and protection should be assured in heritage sites,

exemplifying how public amenity should align with preservation goals. Pedata et al. (2024) showed case studies proving adaptable reuse benefits biodiversity and stimulates societal interaction, of which examples include New York's High Line. Taken together, each study supports the conclusion that bridge designs based on sustainability and heritage should combine technical foundations and local stakeholder views.

Philippine studies investigate similar concerns under local conditions. Gadia et al. (2023) suggested a pedestrian bridge for Bataan focusing on safety and accessibility along major arteries. National Museum of the Philippines (2025) documented Spanish-era bridge preservation at Tayabas to highlight both the structural preservation and cultural value of heritage infrastructure. Cruz and Roldan (2024) noted that cultural heritage integration into infrastructure projects promotes tourism and builds community identity. Gamos (2025) reported Valenzuela's adaptive rehabilitation balancing historical integrity with public purpose. Morales et al. (2022) compared footbridges in Manila and identified lacking safety and accessibility aspects, recommending national design standard compliance. Together, local studies suggest that infrastructure development needs to incorporate safety, functionality, and cultural preservation harmoniously.

`The potential heritage-based promenade bridge for Calumpit Bulacan's Old Bagbag site generates affirmations both internationally and locally. Such projects

reflect how sustainable designs benefit historical remembrance, enhance protection, and encourage continued public engagement.

CHAPTER 3

Research Methodology

This chapter concentrates on the discussion of the research method and procedures that will be taken for the study entitled "Design Proposal of the Heritage-Inspired Promenade Bridge for a Sustainable Old Bagbag Bridge in Calumpit, Bulacan". It discusses the research design, research locale, sampling techniques, research procedure, tools and instruments, validation and reliability, data gathering, and statistical tools.

Research Design

The researchers utilized a quantitative descriptive research design to completely assess and describe the respondents perceptions and evaluation regarding the proposed design and redevelopment of Old Bagbag bridge into a heritage-inspired promenade bridge. This approach focuses on quantitative data or measurable data that reflect the local residents and survey participants. The quantitative descriptive research design ensures that conclusions are drawn from measurable data, from stakeholders, and community members.

Research Locale

The study will be conducted on the site of Old Bagbag bridge located on MacArthur Highway in Barangay Santo Niño, Calumpit, Bulacan, Philippines. The

area has great historical significance as it became the site of the Battle of Calumpit, Bulacan. The bridge is located in a semi-urban area recognized by having a mix of residential communities, small commercial establishments, and agricultural areas. In spite of the current condition of the bridge, it still stands as the local identity and a historical symbol of the past. In this study the researchers will conduct surveys with a purposive sample of not less than 30 respondents composed of LGU, and residents of the region to analyze and ensure that the design will meet the present-day standards while preserving the cultural heritage of the structure.

Research Procedures

The research follows a systematic process to achieve its objective the major steps are outline as follow:

A. **Preliminary Study and Data Gathering:** Compiling accessible plans, documents and historical records of the old Bagbag bridge, and performing a site visit and survey.

B. **Conceptual and Architectural Design Development:** Coming up with design framing inspired by local heritage while embodying sustainability principles and pedestrian functionality.

C. **Structural Analysis and Design Computation:** By employing LRFD approach to design and analyze the structural member of the new bridge using appropriate software tools.

D. **Design Evaluation and Optimization:** Evaluation design performance based on strength, sustainability and serviceability and refining the design based on the analytical and data result.

E. **Validation and Expert Review:** Consultation of professional Engineers, Architects, and Local Heritage representatives to ensure the technical and cultural verification of proposed design.

Sampling Techniques

The study employs purposive sampling to use on selecting the participants based on researchers criteria and characteristics, such as local government officials, engineers, cultural officers and representativeness. This approach guarantees that the information gathered is accurate, comprehensive, and reflective of the diverse perspectives relevant to the study.

Research Instrument

The researchers used two main instruments for data collection. Researchers made questionnaires to gather information from stakeholders and the specialized structural analysis and design software to evaluate the technical performance of the intended bridge. The tools operated sequentially, the survey informed the priorities in conceptual design, and the computer programs determined the structural feasibility of the design and its compliance with current engineering standards.

Software Tools

A. **STAAD Pro:** structural design and analysis is used to determine the integrity, stability and reliability of the promenade bridge to be designed. It will help to calculate important specifications like the load distribution, stress behavior and overall performance based on LRFD standards.

B. **AutoCad:** A software to illustrate the technical drawing and detailed design plans. It is a both 2D and 3D drafting tool to illustrate the bridge layout, elevation, cross section and reinforcement details.

C. **SketchUp:** A 3D making software to show a visualization and conceptual modeling of the proposed heritage-inspired promenade bridge. It allows researchers to show a realistic representation of the bridge that highlights aesthetic and heritage elements.

D. **Microsoft Excel:** Assisting software for organizing data such as structural calculation sheets, summarizing load combinations and verifying computational results obtained from different software. It will also be in use for data tabulation, numerical computation and result analysis.

Validation and Reliability of data

To certify the results accuracy and dependability, the study implements some validation procedure:

A. **Engineering validation:** Licensed civil engineer and structural engineer will review the design computations and structural models to examine and validate.
B. **Software verification:** To validate the analytical results by comparing both manual calculations and software-generated outputs

Data Gathering

The data gathering procedure will focus on four major steps. Including questionnaires together with compiling accessible plans, documents and historical records of the old Bagbag bridge, structural design, visual modeling, and costing.

The questionnaire serves as the introductory phase of data gathering, aiming to acquire perceptions and opinions of local residents, pedestrians, and stakeholders in the surrounding area of the Old Bagbag Bridge in Calumpit Bulacan. A Likert scale questionnaire format is used to assess the public's opinion on matters of safety, functionality, preservation of heritage, and sustainability of the proposed heritage-inspired promenade bridge. The questionnaire will only be conducted in person based, to make sure that the acquired respondents are true to the desired participants of the study and also to ensure that the answers acquired are clear and concise. A statistical treatment of data acquired was done through Percentage and Frequency Distribution, Weighted Mean, and Chi-Square Test to explain the opinions and attitude of respondents.

The structural design phase emphasizes the engineering assessment and creation of a pedestrian promenade bridge, drawing inspiration from the historic Old Bagbag Bridge. This design does not evaluate the current structure but presents a completely new concept that adheres to contemporary structural and aesthetic criteria. Design parameters including dead load, live load, wind load, and seismic load are established in accordance with the Load and Resistance Factor Design (LRFD) methodology, consistent with the provisions of the National Structural Code of the Philippines (NSCP 2015). Software applications such as AutoCAD, and STAAD Pro are employed to simulate and analyze the components of the bridge, assessing their performance under various loading scenarios. The LRFD methodology guarantees that the proposed design attains structural integrity, safety, and functionality while optimizing the use of materials.

The phase of visual modeling offers a scaled or digital depiction of the intended bridge design. This model demonstrates the structural configuration, pedestrian routes, and incorporated park elements that embody contemporary engineering criteria alongside cultural heritage aesthetics. It functions as a visual instrument for assessing spatial design, proportion, and public accessibility of the proposed edifice.

The costing and economic evaluation aspect identifies the financial feasibility of the proposed redevelopment. Quantities of materials, labor expenditures, and construction costs are approximated and summarized with Microsoft Excel and

related estimation software. This aspect guarantees that the proposed design of the bridge stays cost-effective with good quality, sustainability, and cultural value.

Statistical Tool

Percentage and Frequency Distribution

This method is used to present the respondents demographic profiles and summarizes data. It shows the number of participants in each category such as age groups, and residency status. It shows the percentage value that implies the relationship of each category corresponding to the total sample size. This technique emphasizes the pattern in respondents characteristics and shows a clearer understanding of each data point.

Chi-Square Test

The chi-square test is a statistical method used to see if there is a significant or different relationship between two categorical variables. This method provides a statistical foundation on analyzing the data from the survey and validating data.

Likert Scale and Weighted Mean

The Likert scale is utilized to measure the perceptions and opinions of respondents regarding the proposed heritage-inspired design of the Old Bagbag Bridge Promenade. The questions focus on aspects such as safety, functionality as a pedestrian walkway and park, cultural heritage preservation, sustainability, and overall aesthetic appeal of the proposed bridge design.

Scale	Description	Range
5	Very Important / Strongly agree	4.20 - 5.00
4	Important / Agree	3.40 - 4.19
3	Moderately Important / Neutral	2.60 - 3.39
2	Slightly Important / Disagree	1.80 - 2.59
1	Not Important / Strongly Disagree	1.00 - 1.79

Figure 2: Likert Scale

Formula:

$$\textit{Weighted Mean (WM)} = \frac{\sum(f \times w)}{N}$$

where:

f = frequency of responses for each scale point

w = weight or numerical value assigned to each response

N = total number of respondents

∑(f×w) = sum of the products of frequencies and their corresponding weights